

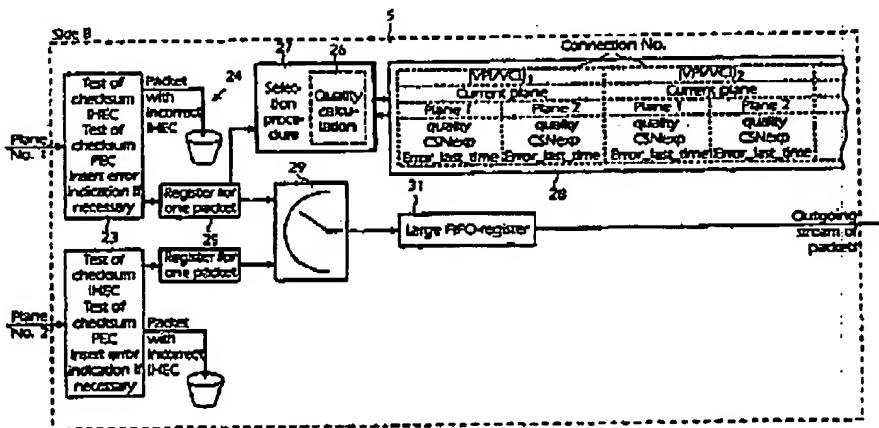
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(34) Title: A METHOD FOR HANDLING REDUNDANT SWITCHING PLANES IN PACKET SWITCHES AND A PACKET SWITCH FOR CARRYING OUT THE METHOD



## (57) Abstract

A switch (1) for the transfer of data packets comprises in the conventional way input ports (3) and output ports (5) and parallel switching planes, which are identical to each other. The switch (1) establishes connections between input ports (3) and output ports (5) through the parallel switching planes. In each output port (5) there is for each switching plane and each established connection a buffer (25) for accommodating at least one data packet. In the output port there is in addition a logical selection device (29) for selecting data packets from the switch (1) and from the different planes in such a way that a data packet stream, which is as correct as possible, is obtained from the output port, and it selects in the first place data packets from a switching plane, which is the preferred plane at each instant. The selection device (29) comprises a quality determining unit, which at each occasion determines the preferred plane by means of quality values for each plane. These quality values are determined by means of an evaluation of data packets, which have arrived earlier to the output port.

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**A method for handling redundant switching planes in packet switches and a packet switch for carrying out the method**

**TECHNICAL FIELD**

The invention is related to a method for handling parallel and independent switching planes in a packet switch and a packet switch by means of which the method can be performed.

**BACKGROUND OF THE INVENTION**

In order that a switch in a network for the transfer of data packets, for instance an ATM-network, will be able to satisfy the requirement of a high reliability, some form of redundancy is required, that is that some parts of the hardware of the switch are made as double or multiple units, which perform exactly the same operations and operate in parallelity to each other. A common way of providing this redundancy is by means of parallel and independent switching planes.

The transfer of data packets in a packet switch may be incurred with errors, so that for instance individual data packets disappear, will be wrongly addressed or that bit errors appear in the data packet. These errors can then be detected, when the data packet is to be forwarded from the packet switch. If several switching planes are provided, the task thus is to grasp and forward, at the output port of the packet switch, only the data packets transferred without errors and also monitor that the data packets are forwarded in a correct sequential order. In packet networks and particularly ATM-networks it is, to some extent, in addition permitted that data packets are lost or discarded. For instance, the buffers necessary for the handling of the statistical multiplexing in a packet switch can be filled, whereafter data packets arriving to the buffer may be lost. Having a redundancy in the switch, for instance with parallel switching planes, this means that the same data packet in the different planes is not available at the same time at the output port of the switch, where the redundancy is terminated, that is in the connection point of the parallel switching planes.

These different errors can, as has been observed above, be

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detected when the data packets leave the individual switching planes to be forwarded from the packet switch. The reliability and the communication quality can here be improved and the forwarding made quicker by selecting "the best switching plane" according to some algorithm, i.e. data packets are selected first from that switching plane which in some respect can be considered to have the best communication quality.

A change of the preferred switching plane must in this case be performed in a controlled way such that, due to the possibly varying communication velocity on the different planes, data packets are not lost or unnecessarily doubled in such a change of preferred plane.

#### PRIOR ART

The European patent application EP-A1 0 381 334 discloses the handling of asynchronous, redundant digital data messages. Several parallel and equivalent communication channels are each one connected to an own buffer. The various data messages which have been received in an arbitrary order are sorted and a majority choice is performed to determine the channels which have correct data messages.

In the European patent application EP-A1 0 453 607 a packet switch is disclosed having redundant switching planes. For each output port of the switch there is an evaluation unit, which receives data packets from the different switching planes and in the common way selects data packets having no errors but also selects preferably or in the first place data packets from that switching plane on which the data packets are communicated in the most slow way. For each connection there is at the output side a counter provided for each one of the switching planes where the counter for a plane, on which a packet has been correctly transferred, is increased by a fixed amount and the counters for the other planes are decreased by another smaller amount. The preferred plane from which packets will be chosen in the first place is the plane having the lowest value in its associated counter.

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## SUMMARY OF THE INVENTION

It is a purpose of the invention to provide a method and a packet switch according to what has been said above having a simple and efficient choice of a preferred switching plane for accessing those data packets which are to be forwarded from the packet switch, permitting that an outgoing data packet stream is as correct as is possible or reasonable.

It is a further purpose of the invention to provide a method and a packet switch according to what has been said above comprising, in the determination of quality of the different switching planes, a detailed evaluation of the stream of data packets passing through the switch allowing an improved choice of a preferred switching plane for accessing those data packets which are to be forwarded from the packet switch.

According to the invention a method and a packet switch are provided achieving the purposes mentioned. The detailed characteristics and the scope of the invention appear from the appended patent claims.

Thus, statistics is collected for the data packets which have been transferred on each switching plane. From this statistics at each instant that switching plane is determined having the best communication quality. Data packets are selected in the first place from this plane until some other switching plane is judged to be better. The choice of a switching plane can be performed either for each packet communicated through the switch to an output unit or port, for each established connection or on each link between an input unit or port and an output unit or port of the switch unit, where on each link thus generally multiple simultaneous connections may be established.

Thus, a switch for the transfer of data packets in the common way has input units and output units and switching planes which are identical and parallel to each other. The switch may advantageously be arranged to establish several logical connections between input units and output units on the parallel switching planes. In each output port there is, for each

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switching plane and possibly in combination with each input unit or port of the switch or with each established connection, a buffer accommodating at least one data packet. In the output unit or port there is a selection device to select from the switch, data packets from the different planes in such a way, that a data packet stream which is as correct as possible is obtained from the output port or resembles as closely as possible the stream of data packets incoming to the switch. The selection device is arranged, in the first place, to select data packets from one, at each instant preferred switching plane. Further there is a quality determining unit provided at the output port, possibly comprised in the selection device, which at each instant, for instance when a data packet arrives to the output port, determines the preferred plane by means of quality values of each plane, which in turn are determined by means of data packets arrived previously to that output port.

Further, it is preferred that the change of a preferred switching plane is not performed until another switching plane has a quality value which is better or higher than the quality value of the preferred plane and which deviates therefrom by an amount which is better or higher than a predetermined value. This will provide a hysteresis in the choice of a preferred switching plane, such that the preferred switching plane is not changed too often. This may be advantageous since hereby the total time consumption of the changes of the preferred switching plane will be reduced.

The currently preferred switching plane can be common to all connections or also be specifically or individually determined for each input port to the switch or for each connection.

In the corresponding way the quality value of each plane may be the same for all connections and input ports or be specifically or individually determined for a considered input port or a considered connection.

In the latter cases then, new quality values for a particular input port or connection and for the switching planes can be

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will, however, become particularly efficient when using a quality value common to the two planes.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described with reference to the accompanying drawings, on which

- Fig. 1 is a schematic picture of a switch having parallel switching planes,
- Fig. 2 is a schematic picture of a switch where all data packets are taken from only one plane,
- Fig. 3 is a schematic picture of a switch, where all data packets from a particular input port always are taken from only one switching plane,
- Fig. 4 schematically shows the handling of a data packet at the arrival to a packet switch,
- Fig. 5 schematically illustrates the handling of data packets at the arrival thereof to an output port of a switch after the transfer through the switch,
- Fig. 6 shows a flow diagram for the choice of an active plane,
- Fig. 7 shows a flow diagram of a subroutine in the evaluation of the best plane,
- Fig. 8 schematically illustrates an alternative handling of data packets at an output port,
- Fig. 9 schematically illustrates a packet counter utilized in the handling according to Fig. 8,
- Fig. 10 shows the format of a data packet transferred through the switch,
- Fig. 11 shows an alternative format of a data packet having control information for a forced control of the handling at the output port,
- Figs. 12 and 13 illustrate flow diagrams of logical procedures which are performed at the output port in the embodiment according to Fig. 8 without and with respectively, a forced control of the handling of data packets at the output port,
- Fig. 14 shows a flow diagram illustrating the handling of a data packet at the arrival thereof to a packet switch.

#### DESCRIPTION OF PREFERRED EMBODIMENTS

In Fig. 1 the construction of a packet switch 1 is schematically

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illustrated. The switch unit 1 comprises inputs at the input side or side A, which are here represented by an input unit or input port 3, and a number of output ports at the output side or side B, which are here represented by an output unit or output port 5. The input unit 3 and output unit 5 are connectable by means of logic of the packet switch, that is the logic circuits inside the switch core, wherein electrical connections or links are established in parallel on n multiple switching planes. A data packet which arrives to side A and thus to the input unit 3, generates n identical data packets which are forwarded on the n switching planes, where the communication of these identical data packets are performed totally independently of each other on the different switching planes. These identical data packets then arrive to the output unit 5 and therein correctly transferred data packets are selected and a sequence or stream of output data packets is created having a correct sequential order of the different data packets. In the output unit 5 thus is selected, in some way, only one of the transferred identical data packets corresponding to an incoming data packet, which has previously arrived to the input unit 3.

In Fig. 2 a switch is illustrated having two switching planes which are numbered 1, 2, and two input ports  $3_1$  and  $3_2$  and an output port 5. In the case illustrated here, switching plane No. 1, is active, i.e. a selection procedure present in the output port 5 selects in the first place data packets which have been communicated on plane No. 1. This is true for all data packets independently of the input port, on which they have arrived to the switch. This selection method may then be indicated as "selection per link". The switching plane, which has been determined to be the best one by means of some election criterion, is set to be active. This choice procedure can very simply be performed in the logical circuits of the output unit, but the disadvantage of this "choice per link" naturally is that single errors in a switching plane, for instance at some intermediate point, through which only some data packets pass, will result in a change of active switching plane in spite of the fact that this switching plane may give a correct transfer of other data packets.

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Another possibility eliminating this disadvantage is illustrated in Fig. 3 for a packet switch 1 having input units  $3_1, \dots, 3_n$ , two switching planes having Nos. 1, 2 and output units  $5_1, \dots, 5_m$ . For a particular considered output unit, for data packets arrived to the switch at a particular input port  $3_i$ , in this case data packets are selected in the first place from one of the two planes. This choice procedure can be indicated as "choice per path". In order to perform the method some identification is required of the input port on which the data packet has arrived to the switch 1. In the case illustrated in the Figure this may be achieved by arranging that in each input port  $3_1, \dots, 3_n$ , the order or logical number 1, ..., n of the input port is inserted in the data packet or added thereto. This number is then used by logic circuits in the output port, to which the data packet is communicated inside the switch, for the choice of a preferred plane for the considered input unit, and the number is here also removed from the data packet. The switching plane 1 can thus be the preferred plane for a certain input and the switching plane 2 for other inputs.

Another possibility for the choice of a preferred redundant plane is given by utilizing information, which conventionally already exists inside or in any case will be added to and inserted in a data packet when it arrives to an input port of the switch, and which is required for the identification of the data packet. Only this case will be considered hereinafter and more specifically the fact is utilized that each data packet belongs to or is associated with a logic connection. Such a logic connection is established through the whole packet switching network (not shown in the Figures), and in particular through each switch 1, when initially a request of the communication of information is received from a terminal (not shown) in the network. This choice procedure may then be indicated as "choice per connection". A modification of the normal procedure at the arrival of the data packet to the switch is thus not required in this case.

In Fig. 4 the handling or processing of the data packets at the incoming side A is schematically illustrated, in a normal

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transfer through a packet switching network, i.e. after arrival of a packet to an input unit 3 of a switch 1, before the data packets are issued on the switching planes, which in the case illustrated here are two. In the following it will also always be assumed that there only two switching planes having the order numbers 1 and 2. In a processing unit 7 particular information is generated, redundancy information and/or administrative information, and it is added to or inserted in a data packet, before it is transmitted simultaneously into the two switching planes Nos. 1 and 2 through a transmission node 9. The generation unit 7 stores and reads required information for its operation from a memory 10 comprising various data fields.

In Fig. 10 the configuration of the data packets is illustrated, after the passage through the generating and processing unit 7. The data packet thus comprises the proper or real information which is to be transmitted through the whole switching network from a source terminal (not shown) to a destination terminal (not shown) and which is located in a field 11, here called "Payload". In addition, the original or real data packet may contain an initial field 13, here indicated as "Header", which can contain both general and other administrative information in regard of the data packet, such as the address of the destination terminal, the address of the source terminal, i.e. the origin address, information relating to priority, channel number, etc.

In the unit 7 for the generation of the extra information required for the transfer of a data packet inside the switch 1 a field 15 is inserted in the data packet containing an internal connection number, called "VPI/VCI", in a field 17 a sequential number, "CSNcell", and two check sums, "IHEC" = "Internal Header Error Check" and "PEC" = "Payload Error Check". The check sums are found in fields 19 and 21 respectively in the completed data packet. The first check sum "IHEC" in the field 19 is thus related in particular to the information comprised in the various administrative fields 13, 15, 17 in the complete data packet, while the check sum "PEC" in the second field 21 is related particularly to the real or original information

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If it can be presupposed that the copies of the same data packet which are communicated on the two planes, arrives to the output 5 approximately simultaneously, i.e. approximately at the same time are stored in the respective registers 25, no resequencing of the communicated data packets or other complicated logic is required for achieving the best possible forwarded sequence of data packets. If for instance a data packet having a particular sequential number "CSNcell" is not found among the packets transmitted over a particular plane, such a logic would be able to try to find this packet among the data packets transmitted on the other plane. It would require a buffer storage for several data packets for each plane at the output port. Such a solution is described in the simultaneous patent application having the title "A method for handling redundant switching planes in packet switches and a switch for carrying out the method", corresponding to the Swedish patent application SE A 9300484-4, filed 15 February 1993 in the name of Ellemtel Utvecklings AB, which is incorporated herein as a reference. However, in the selection procedure of data packets as described therein, data packets are also always selected in the first place from one of the redundant planes. A choice of this preferred plane can be performed in the way described below.

For the handling at the output side some stored variables are required for each currently established connection. They are stored in appropriate data fields in memories or registers indicated at 28 in Fig. 5. For each connection, as specified by the contents of the field "VPI/VCI" in the data packet, there is thus a pointer or indicator "current\_plane" indicating the switching plane preferred at the current instant, from which data packets are taken in the first place. Further, there is, specifically for a considered connection and for each switching plane a few variables, comprising a quality value "quality" and a value "CSNexp" for the expected sequential number of the next data packet which is to arrive to the output side of the switch.

The quality value indicates, based on the earlier communication of data packets, how good the communication is on the switching plane for the considered connection. As alternatives (these

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cases are not shown) the quality value can be the same for one switching plane and all active connections ("choice per link") or for each connection from a particular input port ("choice per path") in a manner in line with the discussion above. In the following it is assumed, for facilitating the description, that a low quality value indicates a good communication while a high quality value indicates a worse communication on the considered plane.

Further, there is a variable "Error\_Last\_Time", also stored in the memory 28 for each combination of connection number and switching plane, which indicates if some error occurred at the reception of a data packet the last time on this switching plane, preferably in regard of only this connection, or as above "per link" or "per path" in other cases (not shown) what would mean that fewer data fields are required in the memory 28 for this variable. In the other cases thus the variable would be valid for reception of packets on this switching plane totally for all active connections or from only a particular input port respectively.

In the following a procedure for among other things choice of a preferred, best switching plane, performed by the selection unit 27 and in particular by the quality unit 26 will be described with reference to flow diagrams and program sequences written in pseudocode for the case where the choice is performed both for each connection and for each plane. In the following, as above, only two switching planes No. 1 and No. 2 are assumed to be arranged in the switch 1.

In Fig. 6 a flow diagram is illustrated for the procedure here of interest which is performed at the output side of the switch 1, i.e. for a portion of the procedures performed in the selection unit 27 and in particular the quality unit 26 of Fig. 5. The procedure starts in a block 401 and then in a block 403 it is determined if any data packet has arrived to either one of the registers 25. If it is decided that it is not the case, the decision is repeated until the reply to the decision in the block 403 is yes, and then in a block 404 the connection, i.e.

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specifically the number in the field "VCI/VPI", is determined, to which the received packet belongs, by reading this information through lines shown in Fig. 5, from the corresponding register 25. Then a decision is performed in a block 405 whether the quality of the currently active or preferred switching plane is sufficiently good. If it is not the case, the active plane is changed in a block 407. The condition of the block 405 together with the block 407 is apparent from the following short pseudocode routine. "delta" is here a number value providing an hysteresis to the decision of the block 405.

```
if quality(current_plane) - delta > quality(standby_plane))
    then change plane
```

The preferred plane is thus changed in the block 407 only if the currently preferred plane (indicated by the variable "current\_plane") has a quality value ("quality"), which is an amount "delta" worse than the quality of the other plane (indicated by the variable "standby\_plane") (in the general case for more than two redundant planes, not as good as the quality of each other plane).

After the test of quality in the block 405 and a possible change of planes in the block 407 a procedure is performed in a block 409 for the measurement and evaluation of the quality in regard of sequential correctness of the data packets earlier and now transmitted on the plane on which the received data cell was transferred. This procedure will be more closely described with reference to the flow diagram of Fig. 7 hereinafter. After this, it is rewarded in a block 411 that a correct data packet has arrived and then the quality value is decremented (a lower quality value means as earlier a higher quality of the plane) for the considered plane by a value "CR" (= "Cell Received"), while the quality value of the other switching plane is incremented, i.e. made worse by the same value "CR". If there would be arranged more than two switching planes, the decrement value for the quality value of the plane on which the packet has arrived could suitably differ from the increment value for the other planes, e.g. the latter value can be smaller than the

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decrement value.

After this it is considered in a block 413, whether there is any error in the data packet field 11 carrying the proper information "Payload", by checking an indication inside the packet if this check sum "PEC", i.e. the check sum related to the field "Payload", has been corrected. If it is true, the quality value is increased (= made worse) by an amount "PE" (= "Payload Error"), and it is performed in a block 415. Then it is checked in a block 417 if the considered data packet has been transferred to the output FIFO register 31 (Fig. 5) to be forwarded from the switch unit 1. If the data packet is a data packet, which thus is forwarded in the output stream of data packets from the switch 1, the quality values of the two switching planes are reduced (= improved) by a value "CT" (= "Cell Transmitted"). After the check in the block 417 and the possible change of the quality values in the block 419 the handling procedure is terminated in a block 421.

Below is given in pseudocode the routine performed in the block 409 in Fig. 6.

```
Procedure(csn_test)

Begin
    if(CSNcell = CSNexp) then
        CSNexp=CSNexp + 1
        report(OK)
        if(Error_Last_Time) then
            report(intruding cell)
            Error_Last_Time:=false
        endif
    else
        if(Error_Last_Time) then
            if(CSNcell=CSNexp + 1) then
                report(single error)
            else
                report(double error)
            endif
        endif
    endif
```

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```
CSNexp:=CSNcell + 1
Error_Last_Time:=false
else
  if(CSNcell=CSNexp + 1) then
    report(lost cell)
    CSNexp:=CSNcell + 1
  else
    report(single error)
    Error_Last_Time:=true
  endif
endif
endif
end
```

In Fig. 7 a flow diagram is illustrated corresponding to this routine. The routine starts in a block 501 and thereafter it is asked in a block 503 whether the sequence number "CSNcell" of the considered cell is equal to the expected sequential number "CSNexp" of the next data packet, which, at the output side of the switch 1, is to be received on this plane for this connection. If it is decided that there is an agreement, i.e. that the data packet arrives in a correct sequential order, in a block 501 the value "CSNexp" of the expected sequential number of the next data packet is increased. Then the value "OK" is reported to a unit, not shown, for an evaluation of the connections. After that it is decided in a block 507 if any error has occurred the last time at the reception of a data packet in this plane, by checking the variable "Error\_Last\_Time" mentioned above. If there was an error the last time, the value "intruding cell" is reported in a block 509 to the evaluation unit. After the blocks 507 and 509 the handling routine is terminated and the program flow is transferred to an end block 511.

If it was decided in the block 503, that the considered data packet does not have the correct sequential order, it is decided in a block 513 whether an error was present the last time, by testing the variable "Error\_Last\_Time". If there was an error the last time, it is decided in a block 515 if the sequential

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number "CSNcell" of the considered data packet possibly could be equal to the expected sequential number "CSNexp" increased by one, i.e. if a single data packet has been lost. If it is decided to be true, the value "single error" is in a block 517 reported to the evaluation unit. If it is not the case, instead in a block 519 "double error" is reported. After the blocks 517 and 519, in a block 521 the expected sequential number "CSNexp" valid for this connection and this plane is made equal to the sequential number "CSNcell" of the considered data packet increased by one. After this the routine is terminated in the end block 511.

If it was decided in the block 513, that there was no error the previous time, it is decided in a block 523 if the sequential number "CSNcell" of the considered data packet is equal to the expected sequential number "CSNexp" increased by one, i.e. like in the block 515, if a single data packet has been skipped. If it proves to be the case, in a block 525 the value "lost cell" is reported to the evaluation unit and further, the expected sequential number "CSNexp" is set to be equal to the sequential number "CSNcell" of the considered data packet increased by one. If it was decided in the block 523 that the sequential number "CSNcell" of the considered data packet does not agree with the sequential number of the data packet after the expected sequential number, in a block 527 the value "single error" is reported to the evaluation unit. After the blocks 525 and 527 respectively the routine is terminated in the block 511.

The various reported values "OK", "lost cell", "single error"; "double error", "intruding cell" can in a not shown evaluation unit be assigned suitable number values or be evaluated in some other way by means of a more complicated algorithm for the modification of the quality value of the considered connection. Below a table is shown indicating the various possible cases in regard of the sequential numbers of the received data packets and the reported values which these various sequences of sequential numbers will generate according to the pseudo code routine above and the flow diagram of Fig. 5.

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<u>Sequential Number</u> <u>(CSNcell)</u>	<u>Situation</u>	<u>Reported Values</u>
k k+1 k+2 k+3	correct	OK, OK, OK
k k+2 k+3 k+4	1 lost packet	lc, OK, OK
k k+2 k+4 k+5	2 lost packets	lc, lc, OK
k k+2 k' k'+1	1 lost packet, new sequence	lc, se, OK
k k' k+1 k+2	1 incorrect packet	se, ic, OK
k k' k+2 k+3	1 incorrect packet, 1 lost packet	se, se, OK
k k' k'+1 k'+2	new sequence	se, de, OK
k k' k" k"+1	1 incorrect packet, new sequence	se, de, OK

Here the designations "lc" stand for the value "lost cell", "se" for "single error", "de" for "double error", "ic" for "intruding cell".

In the simplest case the various reported values "lc", "se", "de", "ic" are assigned different number values which are directly added to the quality value. A choice giving a rather good performance of the procedure can be the following

```

lc = 2
ic = 5
se = 10
de = 100

```

while the reported value "OK" naturally does not give any change of the quality value, i.e. "OK" is set equal to 0.

The corresponding values for the decrement and increment values "PE" (= Payload Error) and "CT" (= Cell Transmitted) described with reference to Fig. 6 can be

```

PE = 2
CT = 1

```

and the balancing increment and decrement value "CR" (= Cell Received) may be set equal to 1.

In a simplified procedure, which only can be applied for the  
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case with two switching planes, there is only one quality value calculated which is used to indicate the quality of the two planes and in this case is called "Packet\_Counter". The handling of the data packets at the output side is in this case illustrated in Fig. 8.

Here it is decided in the units 23 for the testing of check sums of a data packet, whether the check sums "IHEC" and "PEC" are correct and signals indicating the result of the test are transmitted on lines to logic units 33, one logic unit 33 being provided for each redundancy plane. The registers 25 may in this case accommodate for instance maximally two data packets and from a data packet stored in a register 25 the connection number "VPI/VCI" of the packet is read and transmitted on a line to the corresponding logic unit 33.

The two logic units 33 read data from a common memory 35 corresponding to the memories 28 in Fig. 5. When a logic unit wants to write or read data from the common memory 35, the logic unit sends a signal on a line to an access unit 37, which, controlled by suitable synchronizing pulses, monitors that only one logic unit at each instant will have access to the memory 35. In the memory 35, for each connection given by the number in the field "VPI/VCI", the common quality value "Packet\_Counter" is stored and in the shape of a variable "Active\_Plane" an indication of the plane which is currently active. In its other parts the processing at the output side according to Fig. 8 coincides with the processing as illustrated in Fig. 5, except a special function which will be described in detail hereinafter.

The common quality value "Packet\_Counter" is illustrated graphically in Fig. 9. For each received correct data packet from plane 1 the variable "Packet counter" is incremented by one unit and for each received data packet from plane 2 the value of "Packet\_Counter" is decremented one step. Initially the variable "Packet\_Counter" has the value zero and it may further for instance be assumed that then packets are taken from a plane 1. Then perhaps the value of "Packet\_Counter" decreases and thus will have a successively larger negative value. When it is lower

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than a negative threshold value "Threshold\_Plane\_1", plane 2 will instead be active. After this perhaps again the value of "Packet\_Counter" will increase to be higher than a positive value "Threshold\_Plane\_2" and then plane 1 will be active again. The hysteresis is given by the difference of the threshold values "Threshold\_Plane\_1" and "Threshold\_Plane\_2", which corresponds to the constant "delta" mentioned above.

In the logic unit 33 for the handling of data packets from plane 1 a procedure is performed which appears from the following program segment written in pseudocode and is also illustrated in the flow diagram in Fig. 12.

```

Process_Logic_Plane_1
Begin
    if(IHEC_error) then
        "Discard the packet"
        :For an error in
        :IHEC the packet is
        :always to be
        :discarded.

    else
        if(Active_Plane == 1) then
            "Accept the packet"
            :If the plane 1 is
            :active, the packet
            :is to be allowed to
            :pass.

        else
            if(Packet_Counter ≥
                Threshold_Plane_2) then
                "Accept the packet"
                Active_Plane:=1
                :Plane 2 active
                :Check if change of
                :plane is to be made
                :Change of plane is
                :to be performed and
                :then the packet is
                :allowed to pass.

            else
                "Discard the packet"
                :When plane 2 is
                :active and a change
                :is not made, the
                :packet is discarded.

        endif
    endif

    if(PEC_error) then
        Packet_Counter:=Packet_Counter :The packet counter
        :is increased only
    else

```

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```
Packet_Counter:= :for correct packets.  
    Packet_Counter + 1  
endif  
endif  
end
```

The corresponding routine for the logic unit 33 for the plane No. 2 is obtained by swapping the plane numbers and by the fact that "Packet\_Counter" is decreased instead of increased.

In the corresponding flow diagram in Fig. 12 the procedure starts in a start block 1201, whereafter it is decided in a block 1203 whether the check sum IHEC of the present data packet is incorrect. If this is the case, the packet is always discarded in a block 1205 and the procedure is terminated in an end block 1207. However, if the check sum is determined to be correct, it is determined in a block 1209, whether the currently active plane is plane 1, i.e. the plane to which the illustrated procedure applies. If it is the case, the data packet is allowed to pass to the output buffer 31 in a block 1211.

If it was decided in the block 1209, that plane 1 is not active, then plane 2 must be active and then it is to be tested whether a change of active plane is to be performed. It is made in a block 1213, where it is determined if the value of the variable "Packet\_Counter" is larger than or equal to the constant threshold vale "Threshold\_Plane\_2". If it is decided not to be the case, no change of plane is to be performed and then the data packet is discarded in a block 1215. When instead the reply to the comparison is yes, a plane change is to be performed and then in a block 1217 the packet is first allowed to pass to the output buffer 31 and then the active plane is set to be plane No. 1.

Then it is performed in a block 1219, to which the procedure continues also from the blocks 1211 and 1215, a test if the check sum "PEC" for the data packet is incorrect. If it is the case, nothing more is to be performed and the procedure is terminated in the end block 1207. If instead the check sum is

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decided to be correct, the data packet is obviously correctly transmitted through the switch and therefore in a block 1221 the value of "Packet\_counter" is increased. Then the procedure is terminated in the block 1207.

The logical circuits handling the termination of the communication of data packets on the redundant switching planes, have the task of determining, departing from two packet streams, those packets which are allowed to be forwarded. In some cases it may however be necessary to let a superior processor force a control of the redundancy termination. An example of such a case is when performing installation work or updates in a working system. By forcing the redundancy termination to select packets from a particular switching plane, work may be performed on the other plane.

The forced control can be performed by providing each packet with two bits A, B, informing the logical circuits at the output side on the plane, from which the packets are to be taken. These two bits can be added at the input to the switch 1 in the unit 7 (Fig. 4) for generation of redundancy information. The format of the data packet at its passage on the redundant planes may then be as illustrated in Fig. 11. Here there is an extra control byte 39, containing the bits A, B.

The control bits A, B can be coded according to the following table:

Bit: A B

- 0 0 : Handled by the general redundancy procedure
- 0 1 : Packets are only taken from plane 2. All packets from plane 1 are discarded
- 1 0 : Packets are only taken from plane 1, all packets from plane 2 are discarded
- 1 1 : All packets from the two planes are allowed to pass

Since the plane choice bits A, B are carried by all packets communicated through the switch 1, an arbitrary connection may be unconditionally controlled by a superior processor.

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handling of the data packet. These stored plane choice flags can be placed in the memory 28 by some suitable logical routine performed in the selection device 27 and are not described in more detail here.

Below is given in pseudocode the logical procedure performed by the logic 33 for plane 1 comprising the above discussed forced control according to Fig. 8.

**Process\_Logic\_Plane\_1**

**Begin**

```
if(Plane_Select==Plane_1) then
    "Accept the packet"
endif
if(Plane_Select==Plane_1&2) then
    "Accept the packet"
endif
if(Plane_Select==Plane_2) then
    "Discard the packet"
else
```

**Begin**

```
if(IHEC_error) then
    "Discard the packet"
else
    if(Active_Plane(n)==1) then
        "Accept the packet"
```

**else**

```
    if(Packet_Counter(n) ≥
        Threshold_Plane_2) then
        "Accept the packet"
        Active_Plane(n):=1
```

**else**

"Discard the packet"

:Forced control of  
:termination by means  
:of plane choice bits  
:A, B.

:For errors in IHEC  
:the packet is to be  
:always discarded.  
:If plane 1 is active  
:the packet is to be  
:allowed to pass.

:Plane 2 active:  
:Check if change of  
:planes is to be  
:made.  
:Change of plane is  
:to be made and then  
:the packet is  
:allowed to pass.  
:When plane 2 is  
:active and a change

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```

        endif                      :is not made the
        endif                      :packet is discarded.

        if(PEC_error) then
            Packet_Counter(n):=    :The packet counter
            Packet_Counter(n)      :is increased only
        else
            Packet_Counter(n):=    :for correct packets.
            Packet_Counter(n) + 1
        endif
    endif
end

```

The corresponding procedure for the logic of handling of data packets from plane 2 is given by the following pseudo code routine:

```

Process_Logic_Plane_2
Begin
    if(Plane_Select==Plane_2) then      :Forced control of
        "Accept the packet"           :termination by means
    endif                            :plane choice bits
    if(Plane_Select==Plane_1&2) then
        "Accept the packet"
    endif
    if(Plane_Select==Plane_1) then
        "Discard the packet"
    else

        Begin
            if(IHEC_error) then      :For errors in IHEC
                "Discard the packet"  :the packet is always
            else                      :to be discarded.
                if(Active_Plane(n)==2) then
                    "Accept the packet"  :If plane 1 is
                                         :active the packet is
                                         :allowed to pass.

            else                      :Plane 2 active:
        
```

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```

if(Packet_Counter(n) ≥      :Test if change of
    Threshold_Plane_1) then :plane is to be
                            :performed.

    "Accept the packet"    :Change of plane is
    Active_Plane(n):=2    :to be performed and
                            :then the packet is
                            :allowed to pass.

    else                   :When plane 2 is
        "Discard the packet" :active and a change
    endif                  :is not made, the
    endif                  :packet is discarded.

if(PEC_error) then
    Packet_Counter(n):=
        Packet_Counter(n)    :The packet counter
    else                      :is decreased only
        Packet_Counter(n):=
            Packet_Counter(n) - 1
    endif
endif
end

```

In these routines the variable "Plane\_Select" is used as a collective designation of the two plane choice bits A, B. Further, n signifies the connection number of the data packet given by the contents of the field "VPI/VCI". For each connection there is then a variable "Active\_Plane(n)", pointing to the currently active switching plane. The packet counter "Packet\_Counter(n)" will then also be particular for each connection and dependent on n.

In order to agree with the first routine above for plane 1 the flow diagram in Fig. 12 must be modified somewhat, as is illustrated in Fig. 13. Some variables are to be made dependant on the connection number of the data packet and further the forced control is illustrated. The blocks 1301 - 1321 in Fig. 13 thus coincide essentially with the blocks 1201 - 1221 in Fig. 12. Between the start block 1301 and the block 1303 a sequence

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is inserted starting with a block 1351, in which it is determined if bit A of the data packet is set. If it is decided to be the case, the packet is always allowed to pass in a block 1353, whereafter the procedure is terminated in the end block 1307. If bit A is not set, it is decided in a block 1355 whether bit B is set. If it is the case, the packet is always discarded in a block 1357, after which the procedure is terminated in the block 1307. If instead bit B is decided not to be set in the block 1355 - and then bit A not set either - the procedure continues to the block 1303, which coincides with the block 1203 in Fig. 12. The blocks 1309, 1313, 1317, 1321 correspond to the blocks 1209, 1213, 1217, 1221 but apply in the respective cases only for "this connection", i.e. the connection to which the processed data packet belongs.

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## CLAIMS

1. A method for forwarding, from an output side of a data packet switch, data packets in the packet switch,

the packet switch comprising

- an input side with input units for receiving data packets arriving to the switch,
- an output side with output units for forwarding data packets from the switch,
- at least two switching planes which are identical to and parallel to each other,

and the packet switch being arranged in such a way that

- data packets arriving in a sequential order to an input unit of the switch are transferred to an output unit on each one of the switching planes, and
- at an output unit of the switch data packets are selected among data packets transferred on the switching planes in such a way that a stream of data packets is forwarded from the output unit, the forwarded stream resembling as closely as possible a stream of data packets which arrive in a sequential order to the switch and are transferred to the output unit,
- at the output unit data packets in the first place are selected from a currently preferred switching plane, and
- this switching plane is chosen by means of quality values of each switching plane,
- a good or high quality value a switching plane signalling that the transmission of data packets on the plane functions without any essential errors,

characterized in

that this preferred switching plane at each instant is chosen by means of quality values of each plane which have been determined by means of data packets arrived earlier to the output unit.

2. A method according to claim 1, characterized in

- that the quality value of a switching plane is determined by

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means of characteristics or properties of data packets transferred to the output side on this plane,

- these characteristics or properties being derivable only from the streams of packets arriving to the output side on the different switching planes,

- where these characteristics or properties include the sequential order of data packets transferred to the output unit and/or the correctness of at least one data field inside each packet.

3. A method according to claim 1, characterized in that the quality value of a switching plane is made worse or lower when there is an incorrectness associated with a data packet, transferred on that switching plane and received by an output unit.

4. A method according to claim 3, characterized in that an incorrectness associated with a data packet, received by an output unit, includes the sequential order of the data packet in the stream of data packets transferred to the output unit and/or the correctness of at least one data field inside each packet.

5. A method according to claim 1, characterized in that in choosing the preferred switching plane the quality values of the switching planes are compared to each other, their relative sizes determining the choice.

6. A method according to claim 1, characterized in that in choosing a new preferred switching plane

- the quality values of the switching planes are compared to each other, and

- another plane is chosen be the preferred switching plane, if the quality value of this plane is better or higher by a predetermined amount than the quality value of a currently preferred switching plane.

7. A method according to claim 1, characterized in that if a packet transferred to an output unit is correctly received by the output unit, the quality value of the switching plane, on

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which the packet has been transmitted to the output unit, is made better, i.e. given a higher or better value signalling that the transmission on the plane is good, and the quality values of the other switching planes is made worse, i.e. are given lower or worse values.

8. A method according to claim 1, characterized in that the choice of a preferred switching plane is performed each time when a data packet arrives to an output unit.

9. A method according to claim 1, characterized in that a change of the preferred switching plane is not performed until another switching plane has a quality value which is better and higher than the quality value of the preferred plane and which deviates therefrom by an amount which is larger than the predetermined value.

10. A method according to claim 1, characterized in that a currently preferred switching plane for an output unit of the switch is specifically or individually determined for all data packets originating from the same input unit of the switch.

11. A method according to claim 10, characterized in that the quality values are specific or individual for all data packets originating from the same input unit of the switch.

12. A method according to claim 1 in the case where each data packet communicated through the switch belongs to an established connection, characterized in that at an output unit the currently preferred switching plane is specifically or individually determined for a considered connection.

13. A method according to claim 12, characterized in that the quality values are specifically or individually determined for the considered connection.

14. A method according to claim 13, characterized in that new quality values for a particular connection and for the switching plane are determined each time when a data packet arrives to the

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output unit on the considered connection.

15. A method according to claim 1 in the case when the switch has only two switching planes, a first and a second switching plane, characterized in that at an output unit a quality value common to the two planes is used, such that a good or high quality value indicates that the transfer of data packets is better on the first plane than on the second plane, while a bad or low quality value indicates, that the transfer is better on the second plane than on the first plane.

16. A method according to claim 15, characterized in that the common quality value is increased one step for the correct transfer of a data packet to the output unit on the first plane and that the common quality value is decreased one step for the correct transfer of a data packet to the output unit of the second plane.

17. A method according to claim 16, characterized in that the first plane is the preferred plane, when the common quality value is better or higher than a first threshold value, and that the second plane is the preferred plane, when the common quality value is worse or lower than a second threshold value, where the first threshold value is better or higher than the second threshold value.

18. A method according to claim 19, characterized in that when the first plane is the preferred plane and the common quality value is changed to a value worse or lower than the second threshold value, the second plane will instead be the preferred plane, while when the second plane is the preferred plane and the common quality value is given a value better or higher than the third threshold value, the first plane instead will be the preferred plane.

19. A data packet switch for the transfer of data packets, comprising

- an input side with at least one input unit for reception of data packets arriving to the switch,

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- an output side with at least one output unit,
- forwarding means in the at least one output unit for forwarding data packets from output unit and the switch,
- at least two switching planes, which are identical to and parallel to each other,
- connection establishing means arranged to establish a connection between an input unit and an output unit on the parallel switching planes, for the transfer of a data packet arrived to the input unit to the output unit,
- a buffer at an output unit for each switching plane for storing at least one data packet,
- a selection device at the output unit being arranged for selecting data packets transferred from an output unit to the output unit on the at least two switching planes, the selection being made in such a way, that a stream of data packets is forwarded from the forwarding means in the output unit, the forwarded stream resembling as closely as possible a stream of data packets which arrive to the input unit and are transferred to the output unit,
- a pointer at the output unit connected to the selection device and indicating a currently preferred switching plane,
- the selection device selecting data packets in the first place transferred on the switching plane indicated by the pointer,
- quality value storing means connected to the selection device at the output unit for each switching plane,
- means at the output unit for setting the pointer to indicate a preferred switching plane depending on quality values in the quality value storing means,

characterized in

a quality determining unit at the output unit, to repeatedly determine quality values stored in the quality storing means, the quality values being determined by means of data packets arrived earlier to the output.

20. A switch according to claim 19, characterized in

- evaluation means connected to the quality determining unit to evaluate characteristics or properties of data packets arrived

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to the output side on this plane,  
- these characteristics or properties being derivable only from  
the streams of packets arriving to the output side on the at  
least two switching planes,  
- the evaluation means comprising  
- - means for determining the correctness of a sequential order  
in which data packets transferred to the output unit and/or  
- - means for determining the correctness of at least one data  
field inside each packet arrived to the output unit.

21. A switch according to claim 19, characterized in that the  
quality determining unit is arranged to store a quality value of  
a switching plane which is worse or lower than a previously  
stored quality value when there is an incorrectness associated  
with a data packet, transferred on that switching plane and  
received by the output unit.

22. A switch according to claim 21, characterized in  
- means connected to the quality determining means for  
determining the correctness of a sequential order in which data  
packets are transferred to and received by the output unit, and  
- transferring means in a buffer in an output unit which are  
connected to the sequential order correctness determining means  
to transfer a sequential number of a data packet stored in the  
buffer.

23. A switch according to claim 21, characterized in  
- means connected to the quality determining means in an output  
unit for determining the correctness of at least one data field  
inside each packet arrived to the output unit, and  
- transferring means in a buffer in an output unit which are  
connected to the data field correctness determining means to  
transfer the contents of the data field in a data packet stored  
in the buffer.

24. A switch according to claim 19, characterized in  
- comparison means connected to the pointer setting means to  
compare the relative sizes of quality values stored in the  
quality storing means to each other,

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- in setting the pointer to indicate a switching plane the pointer setting means being arranged to make the pointer indicate a switching plane dependent on a result of the comparison made by the comparison means.

25. A switch according to claim 19, characterized in  
- comparison means connected to the pointer setting means to compare the relative sizes of quality values stored in the quality storing means to each other,

- in setting the pointer to indicate a switching plane the pointer setting means being arranged to make the pointer indicate a preferred switching plane if a result of the comparison made by the comparison means indicates that the quality value stored in the quality storing means for this plane is better or higher by a predetermined amount than the quality value stored in the quality storing means for a switching plane, which the pointer currently or previously indicates.

26. A switch according to claim 19, characterized in

- signalling means in the buffer and connected to the selection device to give a signal to the selection device each time when a data packet arrives to the output unit,  
- the selection device being arranged, when receiving the signal, to activate the pointer setting device to set the pointer to indicate a preferred switching plane.

27. A switch according to claim 19, characterized in

- that the buffer in an output unit for a switching plane comprises a buffer for each input unit of the switch, this buffer being arranged to store at least one data packet, and  
- that the quality storing means at an output unit for a switching plane comprises means for storing a quality value for each input unit of the switch.

28. A switch according to claim 27, characterized in

- that the pointer at an output unit comprises a pointer for each input unit of the switch, and  
- that the selection device is arranged to select data packets arrived to an input unit of the switch in the first place which

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have been transferred on the switching plane indicated by the pointer for this input unit.

29. A switch according to claim 19, where the connection establishing means are arranged to establish several logical connections between an input unit and an output unit on the parallel switching planes, such that data packets arriving to the switch, belonging to an information message and which are to be transferred through the switch from an input unit to an output unit, will be assigned such a logical connection, characterized in

- that the buffer in an output unit for a switching plane comprises a buffer for each logical connection from the input units to this output unit of the switch, this buffer being arranged to store at least one data packet, and
- that the quality storing means at an output unit for a switching plane comprises means for storing a quality value for each such logical connection of the switch.

30. A switch according to claim 29, characterized in

- that the pointer at an output unit comprises a pointer for each logical connection from the input units to this output unit of the switch, and
- that the selection device is arranged to select data packets belonging to such a logical connection in the first place which have been transferred on the switching plane indicated by the pointer for this logical connection.

31. A switch according to claim 30, characterized in

- signalling means in the buffers for the switching planes and for each logical connection from the input units to this output unit of the switch, the signalling means being connected to the selection device to give a signal to the selection device each time when a data packet arrives to the output unit on the switching plane and logical connection associated with the buffer,
- the selection device being arranged, when receiving the signal, to activate the pointer setting device to set the pointer for the logical connection of the received data packet

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to indicate a preferred switching plane.

32. A switch according to claim 19, characterized in  
- means connected to the quality determining means in an output  
unit for determining the correctness of a data packet arrived to  
the output unit,  
- signal generating means in the correctness determining means,  
connected to the quality determining means in the output unit,  
for providing a signal, relating to the result of the  
determination of the correctness made by the correctness  
determining means, to the quality determining unit, and  
- the quality determining unit being arranged to store,  
depending on this signal, a new quality value for the switching  
plane, on which the received data packet has arrived, where the  
new quality value is a change of a previous quality value stored  
in the quality value storing means for this switching plane, by  
a certain amount and in such a direction, that the quality value  
will be better or higher for this plane, each time when the  
received signal indicates that a correct data packet has arrived  
to the output unit transferred on this switching plane.

33. A switch according to claim 32, characterized in that the  
quality determining unit is arranged to store, depending on the  
signal from the signal generating means in the correctness  
determining means, new quality values also for the other  
switching planes, each time when the received signal indicates  
that a correct data packet has arrived to the output unit  
transferred on a switching plane, where the new quality values  
are changes of corresponding earlier quality value stored in the  
quality storing means for these other switching planes, by a  
certain amount and in such a direction, that the quality values  
will be worse or lower for these other planes.

34. A switch according to claim 19 in the case where the switch  
has only two switching planes, a first and a second switching  
plane, characterized in  
- that the quality storing means in an output unit comprise a  
memory means for storing a quality value common to the two  
switching planes,

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- a high or good quality value stored in the quality memory means indicating that the transfer of data packets is better on the first plane than on the second plane, and a low or bad quality value stored in the quality memory means indicating that the transfer is better on the second plane than on the first plane.

35. A switch according to claim 34, characterized in

- means connected to the quality determining means in an output unit for determining the correctness of a data packet arrived to the output unit,

- signal generating means in the correctness determining means, connected to the quality determining means in the output unit, for providing a signal, relating to the result of the determination of the correctness made by the correctness determining means, to the quality determining unit, and

- the quality determining unit being arranged to store, depending on this signal, a new common quality value in the common quality value memory means, the new common quality value being a change by one step of a previous common quality value to a higher and better common quality value and indicating a better transfer on the first switching plane, when the signal indicates a correct transfer of a data packet, which is transferred to the output on the first plane, and a change by one step of the previous common quality value to a lower or worse common quality value and indicating a better transfer on the second switching plane, when the signal indicates a correct transfer of a data packet, which is transferred to the output on the second plane.

36. A switch according to one of claims 34 - 35, characterized in

- threshold value storing means in an output unit for storing a first threshold value and a second threshold value, the first threshold value being higher or better than the second threshold value,

- comparison means in the pointer setting means in the output unit for comparing the common quality value stored in the common quality memory means to the threshold values stored in the threshold value storing means,

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- the pointer setting means in the output unit being arranged, dependant on the result of the comparison made by the comparison means, to set the pointer to indicate the first plane as the preferred plane, when the common quality value is higher or better than the first threshold value, and to set the pointer to indicate the second plane as the preferred plane, when the common quality value is lower or worse than the second threshold value.

37. A switch according to claim 36, that the pointer setting means in the output unit are arranged, dependent on the result of the comparison made by the comparison means, to change the pointer to indicate the second plane as the preferred plane, when the pointer indicates that the first plane is the preferred plane and when the result of the comparison indicates that the common quality value stored in the memory means is lower or worse than the second threshold value, and to change the pointer to indicate the first plane as the preferred plan, when the pointer indicates that the second plane is the preferred plane and when the result of the comparison indicates that the common quality value is higher or better than the first threshold value.

38. A switch according to claim 19, in the case where all data packets transferred to an output unit have control information contained therein in regard of the processing of the packet, characterized in

- means at each buffer at the output unit arranged to extract the control information from a data packet stored in the buffer and to output this information to the selection device of the output unit,
- the selection device being arranged, depending on the received control information, either to
- - forward the packet,
- - discard the packet, or to
- - select data packets in the first place transferred on the switching plane indicated by the pointer, the selection in the latter case being made in such a way, that a stream of data packets is forwarded from the forwarding means in the output

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unit, the forwarded stream resembling as closely as possible a stream of data packets which arrive to the input unit and are transferred to the output unit.

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Switching plane No.

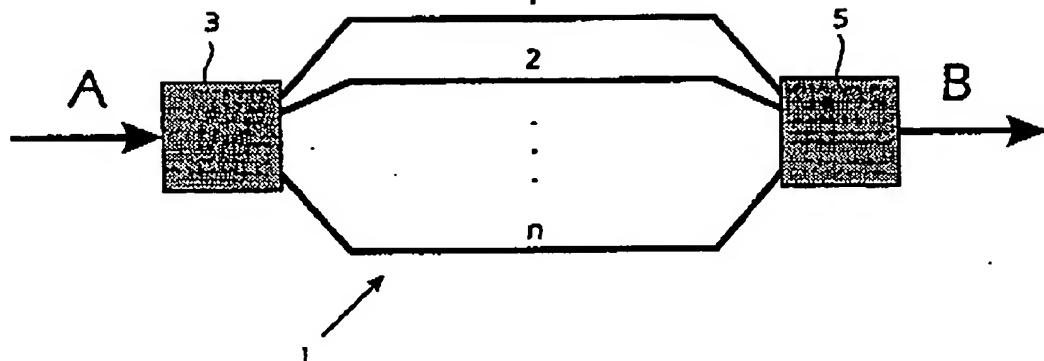


Fig. 1

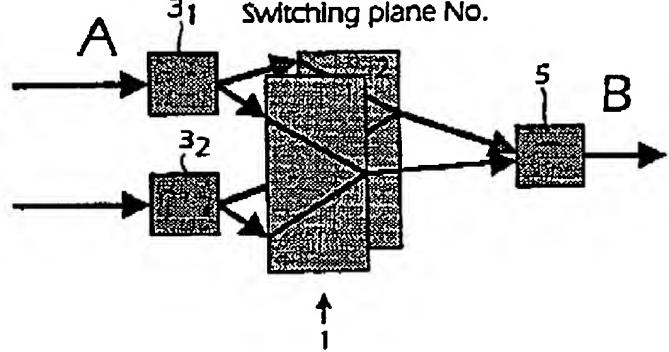
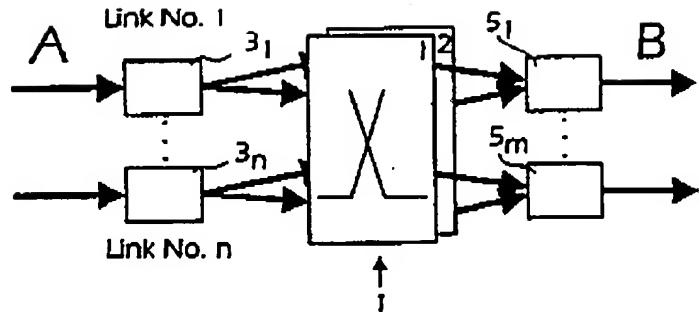


Fig. 2

Fig. 3



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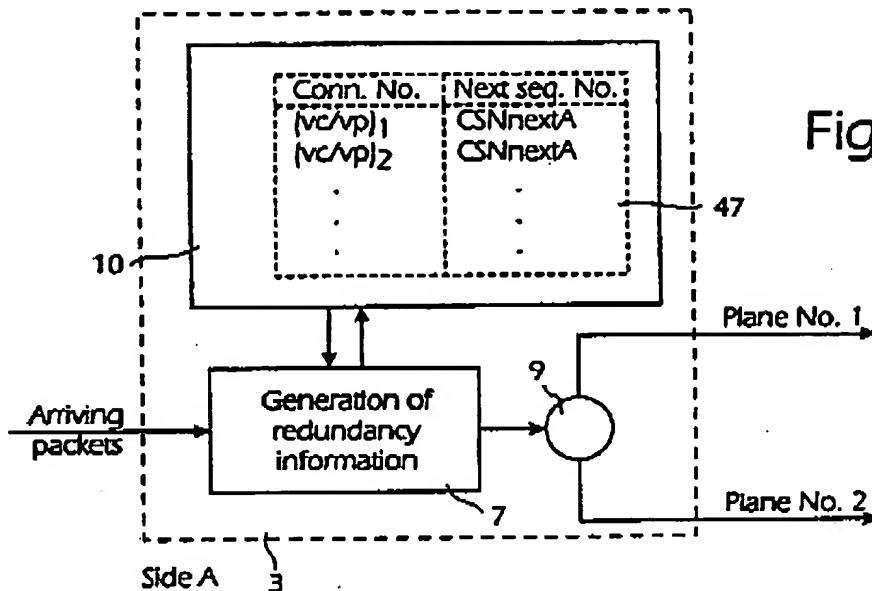
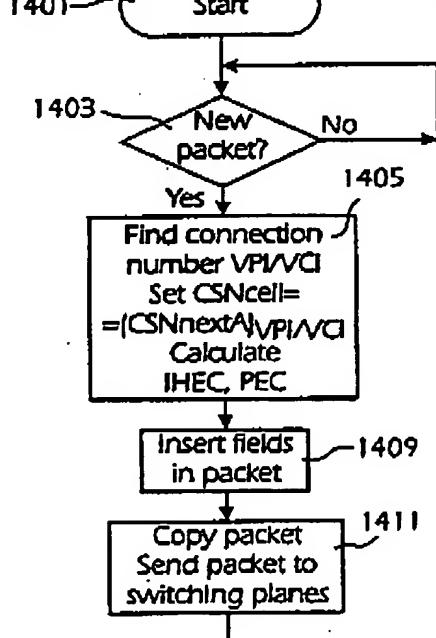


Fig. 4

Fig. 14

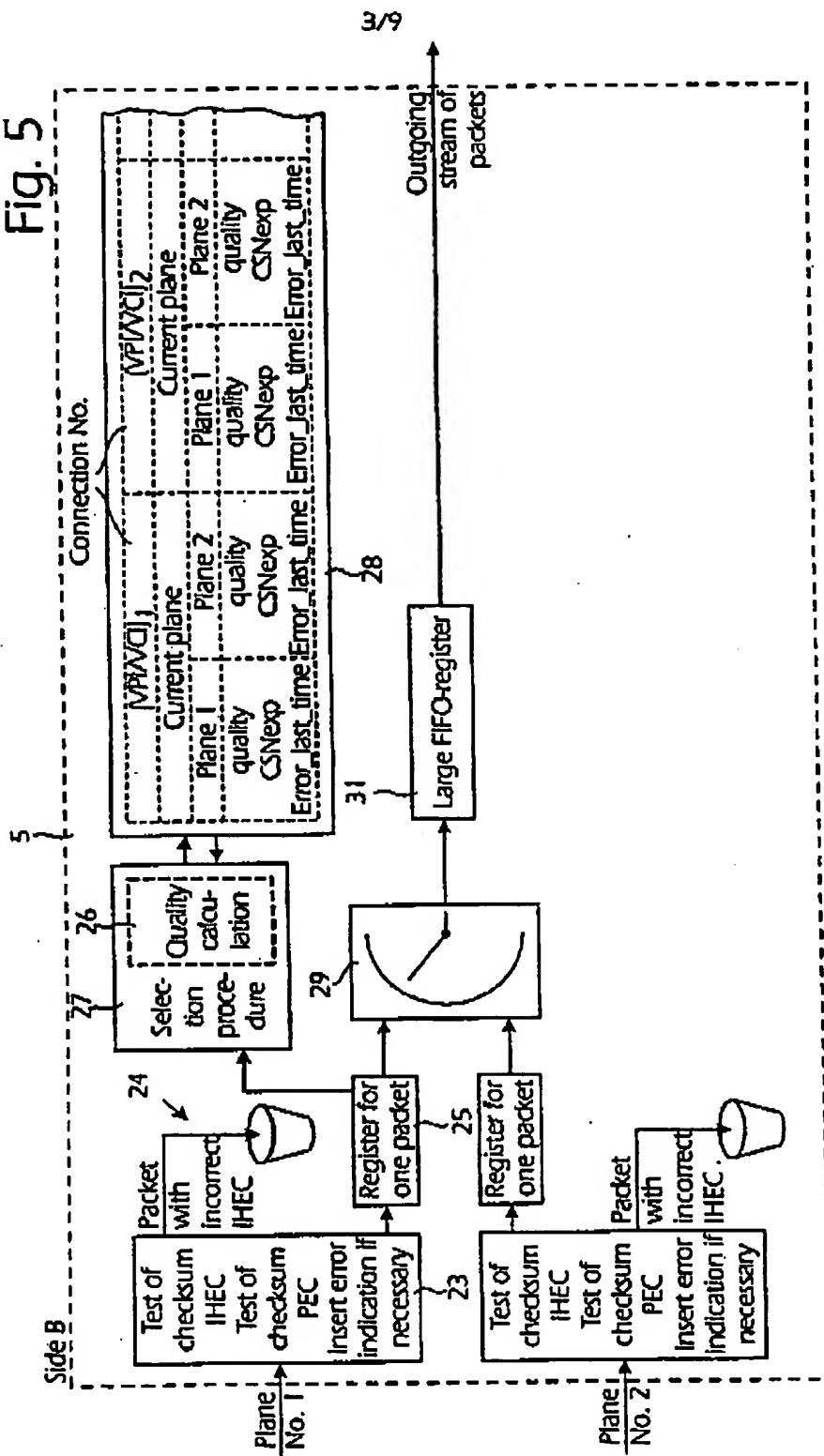


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Fig. 5

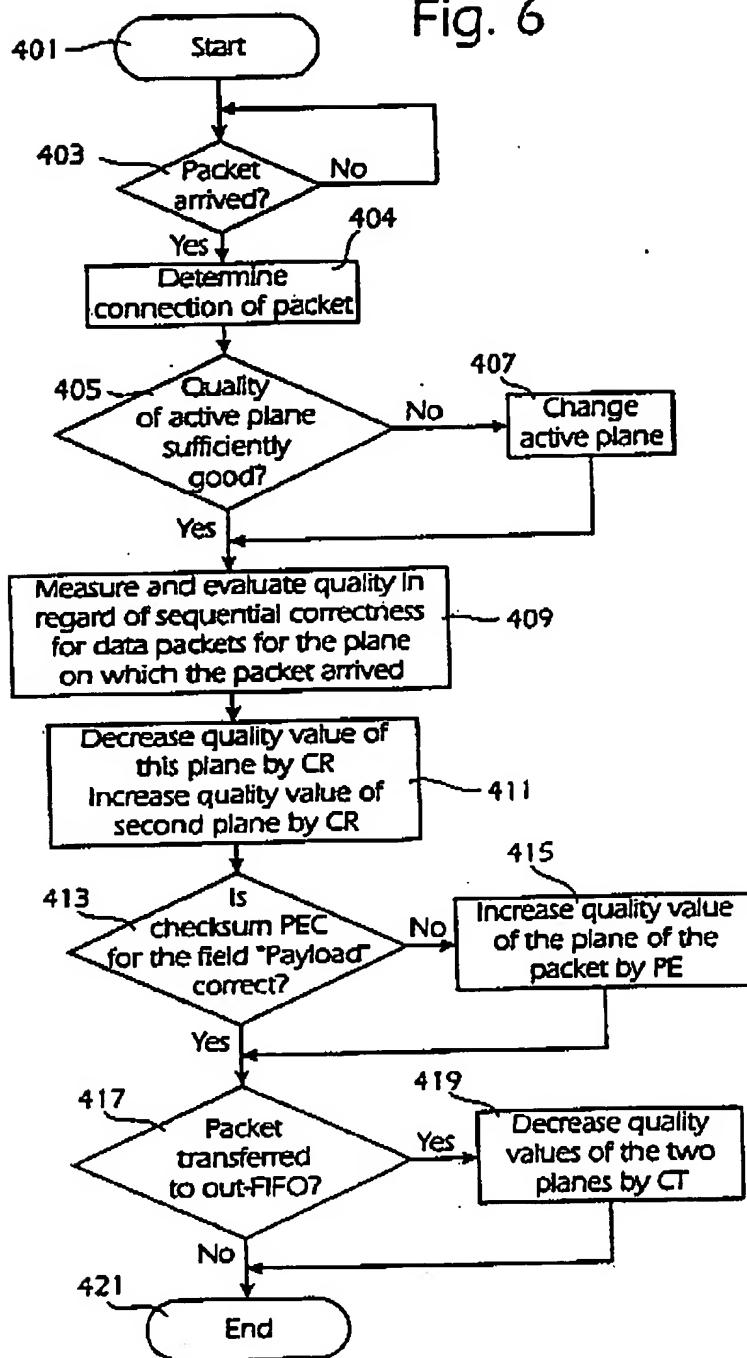
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Fig. 6



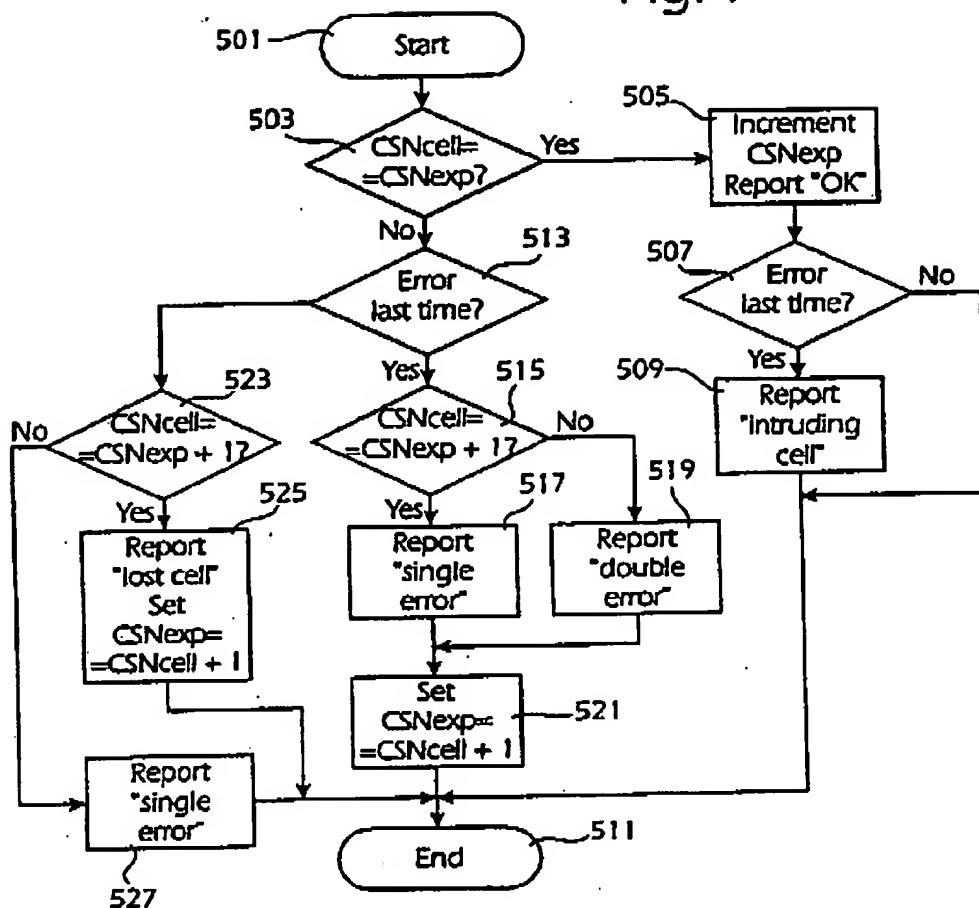
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Fig. 7



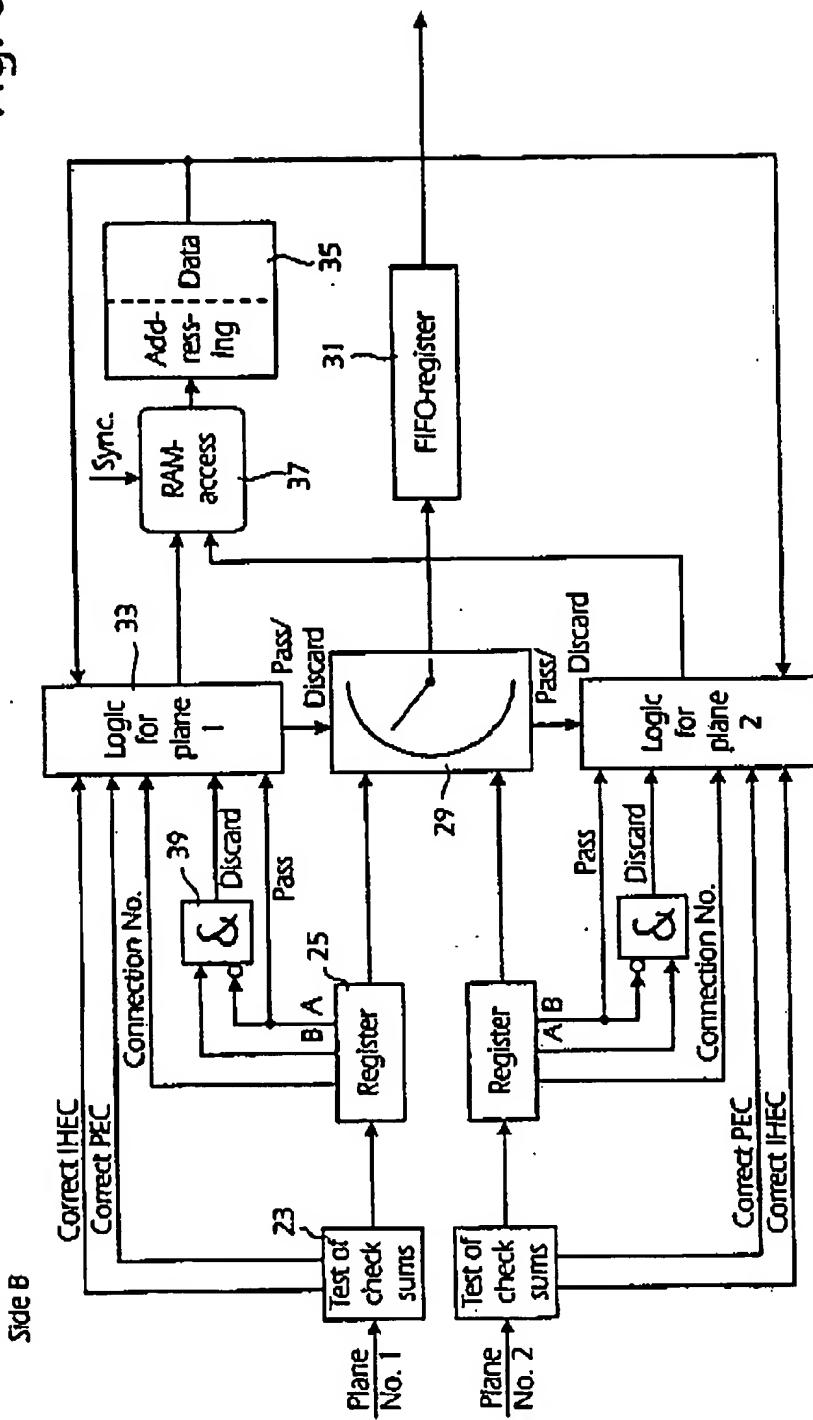
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Fig. 8

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Fig. 10

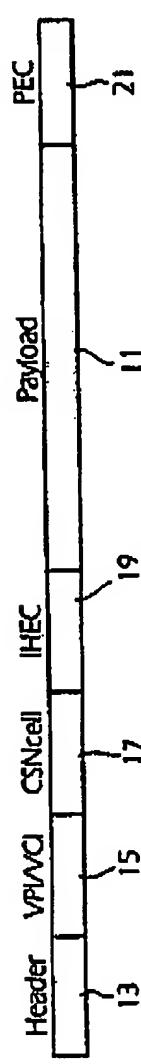


Fig. 11

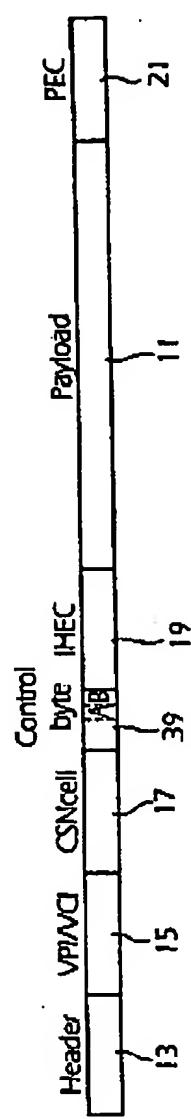
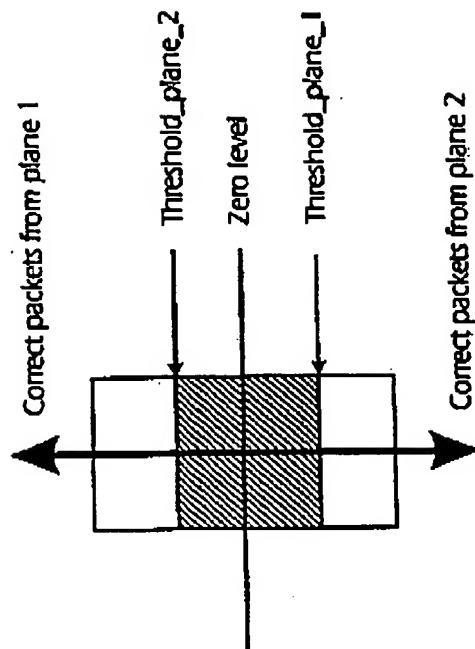


Fig. 9



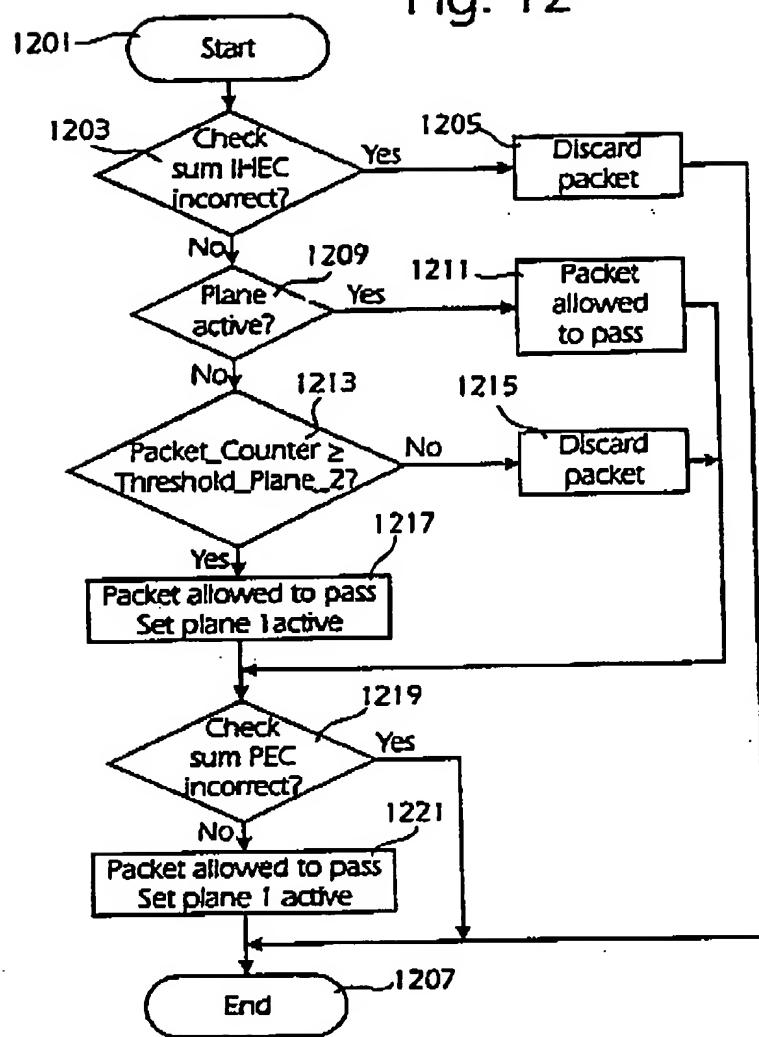
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Fig. 12



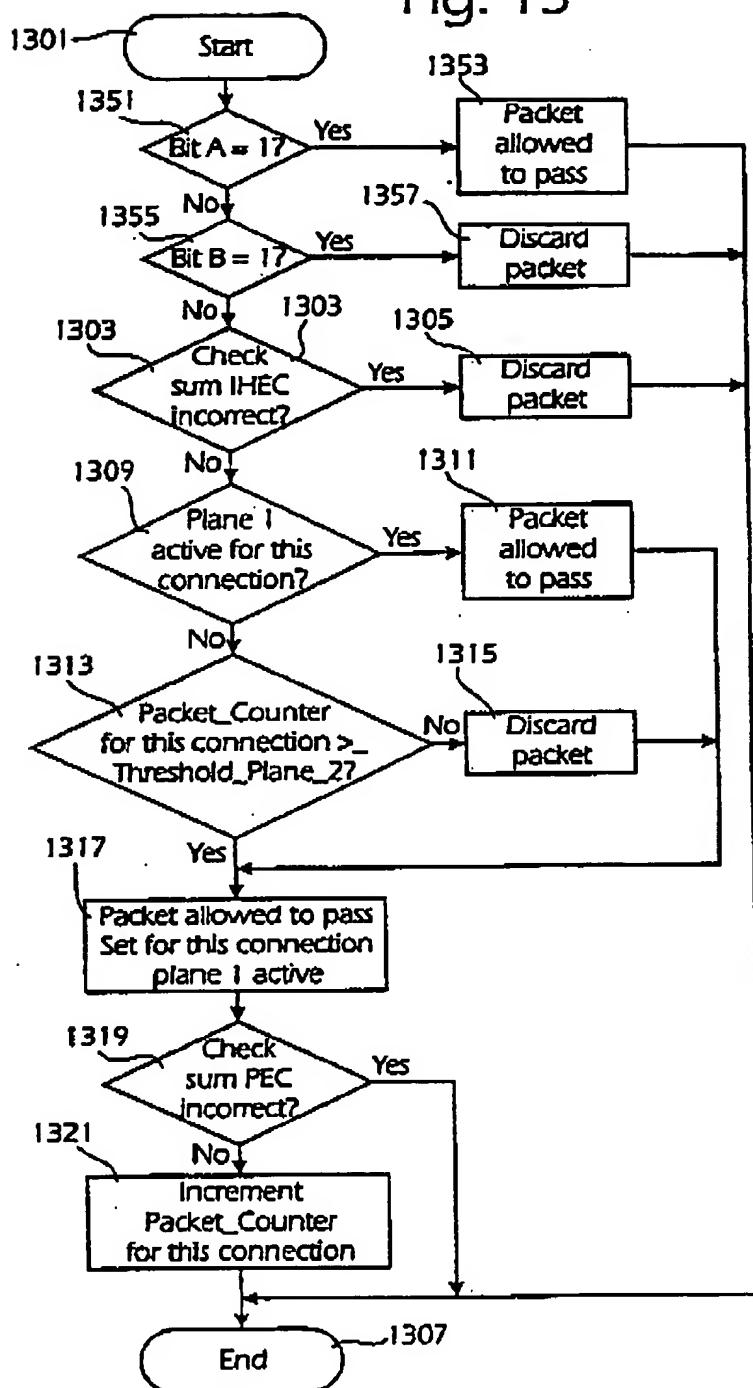
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Fig. 13



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## INTERNATIONAL SEARCH REPORT

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A	EP, A2, 0381334 (ROCKWELL INTERNATIONAL CORPORATION), 8 August 1990 (08.08.90) --	1-38
A	EP, A1, 0384936 (SIEMENS AKTIENGESELLSCHAFT), 5 Sept 1990 (05.09.90) --	1-38
A	EP, A1, 0453606 (SIEMENS AKTIENGESELLSCHAFT), 30 October 1991 (30.10.91) --	1-38

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